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THE RELATION BETWEEN TYPES OF PROBLEMS AND LEARNING OUTCOME

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Abstract: The paper puts forward research results concerning the relation between types of problems and learning outcome in problem-based, project-organized learning. The research indicates, that the students' activities are not only determined by the *content* of the formulated problem (the "what"), but also by *the type* or form of the problem (the "how"). The paper concludes that the learning outcome is related, not only to the content - but also to the type of problem. Consequently educational planning could benefit from taking both content and type of project in consideration, in order to ensure the intended learning outcome.

1. INTRODUCTION

The development of theories and concepts of teaching are in the central part of Europe and in the Nordic countries known as " theoretical didaktik"[1]. Didaktik basically addresses two questions and the relations between them: who is to learn and what is to be learned, the latter addressing both content and the organization of the learning processes (methods).

The aim of our research projects[2] is to contribute to the knowledge of the relation between learning objectives, possible learning outcome and the type of problem-oriented project framing the learning process. This paper deals mainly with one single element in project-organized, problem-oriented projects, namely the relation between the type of project and the learning outcome, and therefore addresses the methodical element in didaktik.

Clarification of the relation between the type of project and learning outcome requires a conceptual frame for categorization of types of projects. We suggest, based on previous research (Laursen, 1994), that the way the problem of the project is formulated offers such a frame. The concept of types must at the same time be so specific that it enables us to distinguish between the different types of problems, and so general that the specific type can include variations within the type.

The relation between the activities of the students and the learning outcome is complex. Our point of view, as formulated in the evaluation of the first year studies at the Faculty of Social

[1] We use the German and Nordic word **didaktik**, as there is no corresponding word in English. The English word didactic/didactics which is *"The most obvious translation of didaktik is generally avoided in Anglo-Saxon educational contexts, and refers to practical and methodological problems of mediation and does not aim at being an independent discipline"*(Introduction: Didaktik Meets Curriculum, Gundem & Hopmann 1998. Didaktik hence denotes *both* the scientific discipline constructing theories of teaching, and thereby offering teachers and educational planners theories and terms to think and talk about teaching, *and* the relation between teaching an learning and the practical planning and evaluation of teaching an d education. Didaktik therefore has a theoretical and a practical aspect.

[2] Parallel research projects are carried out on the basic studies at the Faculty of Social Science and on the basic studies at the Faculty of Engineering and Science, Aalborg University, Denmark.

Science at the University of Aalborg (Laursen, 1994: 53), is that *"We are left to indications of learning, often of a doubtful character. In this study, I have chosen to conclude, that what you try to do […] you may possibly learn […] but you will never learn, what you don't try to accomplish. This means, that high ambitions and complex problems in itself offers no guarantee for the learning outcome, while on the other hand, we can be sure that the scientific and methodical elements which not are addressed, neither are to be learned"*

Evidence for this assumption can be found in the epistemology of constructivism, which includes a number of different attempts to understand the relation between interaction and learning.

2. THEORETICAL POSITION

The epistemological take-off for our research is the radical constructivism formulated by Gregory Bateson (Bateson, 1972). In Batesons epistemology, learning is closely related to changes in behaviour or understanding.

According to Bateson the three fundamental elements in the learning processes are:

- *Adaptation*, stating that changes is conducted by the efforts of the individual to establish or maintain desirable interactions or relations to its surroundings. Learning is therefore closely related to and initiated by problems or disruptions in the interaction between the individual's expectation to a specific situation and the actual situation

- *Constructivism*, which means that knowledge is a construction based on selective perception of differences in the external world. This idea lies behind one of the most well known statements of Batesons, saying that "the map is not the territory"

- *Interaction*, stating that the individual learns by interacting with the surroundings. Every act is based on an expectation of an successful outcome (response), and the actual outcome is perceived and compared with the expectations in order to confirm or disconfirm whether the specific act was appropriate or not. This interaction is in general and in this article often referred to as 'the learning process'

The consequence of this epistemological position is that feedback mechanisms become crucial to what is learned, and that the feedback patterns in the learning process therefore must be established within the frames of the learning objectives and the students' knowledge.

Working with problem-oriented, project-organised learning processes, the project together with the supervision from the teacher becomes significant factors in the feedback patterns. In the following presentation we solely address the feedback patterns created by the project.

The feedback patterns created by the project, and hence, what *may* be learned, are created both by the themes addressed in the project (the content) and of *how* the content is addressed. This how is conducted by the formulation of problem.

The basis of our research is then, that the activities of the students and the possible learning outcome of a problem-oriented project are not solely determined by the content but also by

the type of the problem, that is, determined by the kind of questions that are put forward in the project.

Before addressing this theme further we will introduce the fundamental concepts of problem-oriented, project-organized education.

3. PROJECTS AND PROBLEMS IN UNIVERSITY STUDIES

At Aalborg University 50 % of the educational activities are organized from the concept of learning trough participation in project-organized, problem-oriented activities. In the following we shall introduce the general principles in this teaching method.

By a *project* we mean activities carried out in order to fulfil a specific objective within a limited period of time and through application of planning and conducting activities such as selecting and prioritising content and scope of elements. Concerning projects in educational contexts the objective of the project must be framed by and in agreement with the overall objectives for the study. Furthermore a project is also the result or product of this process. Typically it will be a written rapport, which is to become the object of a formal evaluation of the students' learning.

Project-organization therefore, in our understanding, expresses one among other possibilities for organizing and framing the students' learning processes. The method is originally based on the assumption, that the very context of problem-oriented projects enables the students to understand each element of the study as a relevant element in a meaningful whole. This way of thinking is well known for example from the work of John Dewey (Illeris, 1974; Illeris, 1981).

Our understanding of the concept of *problem* is related to our epistemological point of view, saying that learning is initiated by mismatch between the expected and the actual, or between the actual and the wanted. Problem may also reefer to a more common sense use of the word, hereby indicating, that the subject of the project must be something, which somewhat peculiar is called 'real' problems (e.g. problems to somebody outside the educational system) (Illeris, 1981; Klafki, 2001). In our point of view this understanding introduces an inexpedient and normative founded distinction between real and not-real problems, indicating that cognitive or even theoretical problems are not-real problems. When the student's learning are chosen as point of reference the request to a problem will be whether it challenges the students knowledge and invites to cognitive activities. In this sense all problems relevant in educational contexts must be cognitive problems, that is, problems to which the students not from very beginning know the solution.

From the view of the dominating tradition of didaktik in Denmark and Germany a problem must fulfil two criteria in order to form an appropriate context of learning.

The first criterion enunciates that the problem must be subjectively relevant for the students. It means that the cognitive mismatch between the actual and the wanted knowledge must be of such a character, that it becomes relevant and meaningful for the students to try to reduce the mismatch. This criterion is often summarized in the idea about 'participants control' (Illeris, 1974; Illeris, 1981; Ulriksen, 1997).

The second criterion enunciates that the problem and the learning objectives to be fulfilled through the project must be relevant for the specific education. This means that the student through the project must be urged to fundamental and relevant theories, concepts and methods within the field of content (Illeris, 1974; Illeris, 1981; Laursen, 1994; Ulriksen, 1997).

Laursen (2002) has proposed that these two criteria are seen as complementary to each other, while other researchers have seen them as conflictive or even incompatible (Illeris, 1974; Illeris, 1981; Ulriksen, 1997).

Comparable to the assumption of incompatibility of the two criteria, the choice of a project-organized, problem-oriented frame for learning often has been considered as a rejection of a subject or discipline oriented organization of the learning processes (Ulriksen, 1997:22).

Nevertheless any application of project-organized, problem-oriented learning activities within formal educations implies that the apparent incompatibility between subjective and objective criteria as well the proposed incompatibility between discipline-structured and project-structured activities are overcome. This requires the development of a compromise, where both the content and the questions addressed in the project supports the fulfilment of both professional (e.g. theoretical and methodical subjects) and personal aspects within the all over learning objectives.

When we imply that the incompatibility seem to be more a disagreement as to principles rather than a problem for the practical didaktik, this point of view is based on two considerations:

First, that the students in higher education generally have a subjective and personal interest in the subjects of the education, they have chosen. Therefore it should be quite simple for the students to find problems that at the same time create a cognitively and subjectively challenging frame for learning within the all over learning objectives.

Second, that subjects and disciplines historically have emerged through the preoccupation of and the work with specific sets and types of problems. Hence any subject or discipline is constituted of given problems and at sudden way of addressing these problems. Project-organized, problem-oriented work within an education therefore may be closely related to the specific traditions of the disciplines rather than conflicting to these.

The common practice within the formal educational system in Denmark seems to describe a movement where the determining criterion has bee displaced from the criteria of subjective relevance towards the criteria of learning objectives determined by the field of study. Through the control of the content the educations make sure that the students are introduced to fundamental subject areas. How these subject areas are transferred into specific learning objectives through the formulation of the guiding problem never the less still seems to be a decision of the students alone or an affair between the students and the teacher.

However, from our point of view the question of what the students may learn through a specific project does not only depend on what content the project addresses. It is furthermore to a great extend determined by the specific context of feedback patterns, established through the process of working with the project. These feedback patterns are closely related to *how* the

content is addressed. That is to how the guiding problem is formulated, or in other words which type of guiding problem that conducts the students' work with the project.

For example a formulation of the guiding problem, which express that the project aims to propose an explanation of the relation between a given process and the most obvious consequences of the process, at the same time defines fundamental restraints for the project and leaves options open to the students. The type of the guiding problem therefore, with a formulation borrowed from Bateson, determines the context, which the students try to adapt to, and hence becomes the frame for the ongoing comparison between actual and wanted knowledge and skills.

4. DIFFERENT TYPES OF GUIDING PROBLEMS IN THE PROJECTS

Based on analysis of students projects from the first year of the studies at the Faculty of Social Sciences Laursen (Laursen, 1994) proposes that projects may be categorized into three main types based on a set of different ways of formulating of the guiding problem. Each type of problem addresses specific aspects within the complex domain of the scientific field. Hence the choice of formulation of the guiding problem creates a specific system of feedback patterns between the student and the content, and thereby a specific context of learning. In other words, the specific way the student chooses to formulate the guiding problem, determines to a great extend what is likely to be learned, and what is unlikely to be learned.

The three main types of guiding problems that were identified are named (Laursen,1994:55):

- The *descriptive problem* – often formulated as a "What is…"
- The *explanatory problem* – often formulated as s " Why is…"
- The *problem solving problem* - often formulated as a " How can…"

Working on a project conducted by a *descriptive problem* creates at set up for the students' activities, where the task is to describe a phenomenon. This phenomenon will be of different character depending whether we are talking social science, natural science or humanities, but the description will always be based on more or less explicit formulated interest of knowledge and a hierarchy of priorities concerning the various aspects of the phenomenon. Within the category of descriptive problems two sub-types of guiding problem may be identified: (a) the *purely descriptive* form and (b) the *evaluating form*, where the phenomenon are described and evaluated in the light of specific criteria.

The possible learning outcome of descriptive projects is related to the feedback patterns created during the project. These feedback patterns are related to a much broader context than the project, but specifically in relation to the descriptive project the student may learn:

- About the content or the specific phenomenon
- To produce data or information relevant for a specific interest of knowledge
- To produce data and descriptions considering scientific methods and criteria
- To evaluate the quality and reliability of data, information and descriptions
- To understand the relation between the method used and the knowledge produced.

The descriptive problem may be regarded as the most fundamental type of problem, which at the same time forms a category it self and makes the condition for working with problems in the other categories, as the premise for explaining or solving a specific problem is a preceding

description of the phenomenon and its basic elements. Never the less it must be emphasized that the description not only has its relevance as a take off for explanation or problem solving.

Working with an *explanatory problem* the activities of the student aim to produce an explanation of the relations between various elements or phenomena in a given field of study. In the explanatory project the students go beyond the pure description and try to explain *why* things are, as they seem to be. The explanatory project hence focuses on the *relation* between elements of or causes to a given phenomenon. For this purpose concept like actors, structures, functions, forces are often introduced in the descriptions.

Similar to the descriptive type of guiding problem also the explanatory problem can be distinguished in a set of sub-types: We indicate three sub-types as: (a) problems dedicated to the search of *causes*; (b) problems dealing with a *paradox* and (c) problems addressing the test of a *hypothesis*.

What may be learned through the feedback patterns created in the explanatory project is in addition to the learning outcome of the descriptive part of the project:

- Analysing and explaining relations between elements and phenomena within the field of study
- Understanding and using theories and methods to produce explanations from scientific criteria. Theories are in other words used to explain why relations are as they seem to be and how they emerge and take form
- Making critical evaluation of the theoretical based explanations, including references to various criteria concerning the validity of scientific explanations

The explanatory type of problem creates at the same time a relevant, interesting and very demanding context of learning. Working successfully with this type of guiding problem requires, beyond basic knowledge in relation to the content, that the students are able go beyond the data given, and that they are able to use relevant theories to formulate relations between single elements. In other word: the students must be capable to handle a great complexity.

One of the main questions regarding explanatory projects is the question of *relevance*. Do the applied theories and concepts provide explanations that enable the students to throw light on the addressed relations in a way that goes beyond everyday understanding? Another basic question is the question of *validity*. Do the explanations, which the theories enable us to put forward, provide a sufficient complex and precise description an explanation of the phenomenon and the relations between elements?

Working with the third type of guiding problem, the so called *problem solving* problem the aim of the project is to elaborate suggestions concerning how a specific problem may be solved in order to satisfy explicit formulated criteria. Often this kind of project are attended with ‘practical’ problems, for example how to reduce the emission of sulphur containing components from energy production, or how to carry out educational reforms which at the one hand ensure a homogeneous level of knowledge across the nation, and on the other hand allows the schools to have a certain degree of self-determination. Still it is important to keep in mind that the demand to the problem is, that it constitutes a cognitive, but not necessarily a real or practical, challenge.

Problem solving projects may be categorized into two sub-types, which we have chosen to indicate: (a) *Application* of fundamental methods and techniques within an area of praxis or a profession. Focus of the students' learning is on how to solve projects in a context, which to a great extent is intended to be similar to the professional work. (b) *Theory based analysis* of phenomena in a complex context in order to identity key relations and on basis of these formulate at strategy for solving the problem. Projects carried out within this type of guiding problem may be assumed to a greater extend to enhance innovative strategies among the participants.

The two sub-types distinguish themselves from each other in relation to the complexity of the problem. Type (a) is based on the assumption that the problem is already defined or even formulated, whereas in type (b) a main part of the project addresses the analysis that leads to identification of the problem. Regarding the content of the project the focus of the learning process in type (a) is put on the result and the process that leads to the successful result, whereas the focus in type (b) is put on the process that leads the students toward the specific solution and on the relations between theoretical understanding and practical solutions. Both types of problem solving projects require, as do the explanatory projects, a fundament of knowledge consisting of description of and theories about the phenomenon.

The possible learning outcome from the feed back patterns created in the problem solving projects can be divided into several themes:

- Learning about the phenomenon; content and relations between elements
- Learning how to use theories to analysis of complex contexts
- Learning how to identify and formulate strategies for solving of problems
- Learning how to solve problems within a specific theoretical and professional frame

5. RELATIONS TO OTHER ELEMENTS IN THE EDUCATION

Project-organized, problem-oriented activities are seldom the only method used by an education to facilitate the students' fulfilment of the learning objectives. The method therefore must be considered as an element in total aggregate of educational activities in order to ensure that the single element supports the all over objective instead of counteracting it. Exactly this effort is a fundamental element in didaktik (Jank and Meyer, 1994; Klafki, 2001; Keiding, 2002).

In the following section we will address two aspects that we find crucial within this field of topic, namely

- The interplay between project-organized, problem-oriented activities and courses
- The guiding problem as support to self-reflection
- The interplay between project-organized problem-oriented activities and courses

The courses taught through an educational progress and the project must be seen as a double-sided interplay. On one side the courses, whether they address theoretical or methodical subjects, sketches a disciplinary landscape and a structure of relevance and hereby contributes to outline the field of study. The content of the projects and the guiding-problems hence must be articulated within this frame.

On the other side the guiding problem - once formulated by the students - defines the criteria of relevance through which the students observes the courses, and hereby accentuating some

elements of the education as being more relevant than other. Courses that are considered relevant and informative from the perspective of the guiding problem tend to be of profound significance. The guiding problem in other words becomes a criterion that the students may use to make selections and priorities in relations to the courses.

Considering the development of the projects within an education both sides must be taken in account. The courses taught must be planned in respect to content, scope and form in such manner, that they really do offer the students a structured overview of the field of study that is considered relevant and suitable for the specific part of the education. To avoid that the students, using the criteria extracted from the guiding problem, judge elements in the courses as irrelevant, the content of the courses must be explicitly motivated in relation to the educational progress as whole.

In our opinion, the responsibility for accomplishing this double-sided task solely belongs to the education and the teachers, as the students cannot be expected to possess the necessary overview to make the actual relations between the elements of the education. If the students fail in identifying these relations, the consequences may be, that they judge some courses irrelevant or useless, a condition well known from the first year of studies at the Faculty of Social Sciences and the Faculty of Engineering and Science (Laursen, 1994; Algreen-Ussing and Dahms, 1995), all though the conclusions draw by the authors on basis of these observation are widely different.

Previous research (Laursen, 1994) has shown that not only the content, but also the type of the guiding problem have a significant effect in directing the interests of the students in relation to lectures and seminars offered to them. If the guiding problem of the project is, what we name an explanatory problem, the students will 'need' theories and models, which can be used as an explanatory tool, and consequently they tend to be motivated for actually learning these models and theories. The same research offered examples on mismatches between the kind of theories offered by the courses and the kind of theories, that were necessary in order to carry out the projects as outlined by the guiding problem (Laursen, 1994:71-83).

As we see it, examples like this give evidence to the opinion, that the form or type of the guiding problem in relation to student projects is an important element in establishing a mutual supporting relation between the work the students carry out in relation to the projects and the lectures offered in a project-organized study.

6. THE GUIDING PROBLEM AS SUPPORT TO EVALUATION, TUTORING AND SELF-REFLECTION

Apart from having a significant function in guiding the students' self-directed learning activities, the guiding problem furthermore contributes to the framing of the learning process in three ways.

First, the formulation of the guiding problem indicates together with the courses taught the starting point for *the evaluation* of the students' performance in order to decide whether learning objectives are fulfilled or not.

Second, the guiding problem plays a crucial role in the ongoing *supervision* of the students, where the teacher uses the guiding problem as criterion for choosing subjects, themes and

structure of the supervision. The focus here is not the final evaluation of the completed project, but on the continuously ongoing formative evaluation of the progress of the project and of the learning processes of the students.

Third, the guiding problem should constitute a point of reference for *self-evaluation* of the students. An essential premise in project-organized, problem-oriented methods is, that the students possess a wide-ranging responsibility for the project, concerning objectives, content and progress. Projects constitutes therefore to a great extend self-directed frames of learning. Consequently the ability of the student to continuously evaluate and adjust content, methods, quality and sufficiency of their own activities becomes crucial for a successful outcome of the project. In this process the guiding problem becomes a useful tool, as it offers a point of reference against which the efforts can be measured. The activities, which we here collect under the term self-reflection, are closely related to what is called *meta-cognitive* activities.

7. PERSPECTIVES AND RECOMMENDATIONS

In the last decades the attention of educational research and theoretical didaktik has focused primarily on the formal aspect, leading to a renewed search for the final method (Luhmann and Schorr, 1999:122), thereby neglecting fundamental aspects of didaktik as well as epistemology.

First, that learning outcome may be rendered by, but are never guaranteed by teaching and that the learning outcome is determined of at least three elements, namely the learner (who), the subject matter (what) and the method (how). All these elements framed by the fundamental of any education: the learning objectives.

Second, that the how, when regarded as an adaptive context of learning, can not adequately be considered as a choice between methods, but also must address the question of *how* a given general method are concretised.

In this article we address the question of the possible learning outcome of project-organized, problem-oriented educational activities. Based on previous research we argue, that the learning potential of this method widely is determined of the formulation of the guiding problem. Through the formulation of the guiding problem the students create a frame where some aspects of the problem are more likely to be addressed than others. *How* the guiding problem is formulated in other words constructs the subject matter and methodical context that the students through the work with the project try to adapt to.

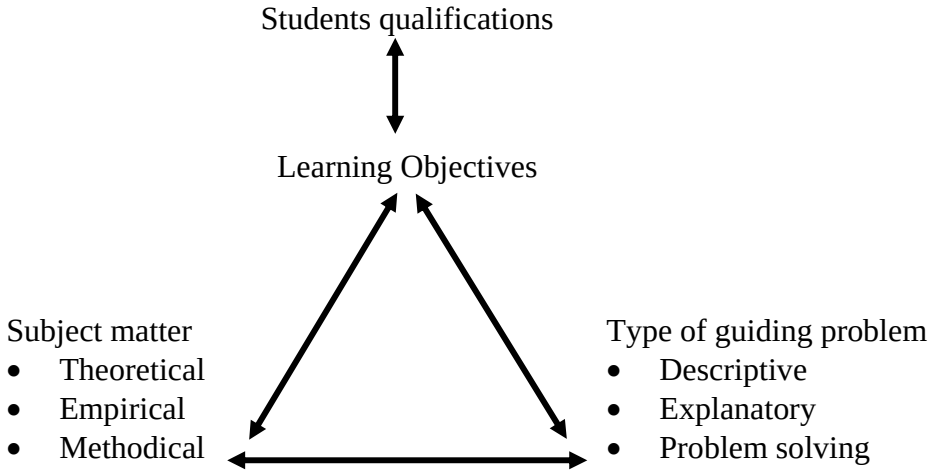
We suggest that problem-oriented projects on the basis of the formulation of the guiding problem may be classified into three categories: the *descriptive* project, the *explanatory* project and the *problem-solving* project. Each type addresses the subject matter in its own specific way, and thereby creating distinct contexts of learning.

The choice of which type or types of guiding problems that are considered relevant at a given time in a given education are closely related to the learning objectives for the period considered, hereby accentuating the fundamental questions of didaktik: *Who* is supposed to learn *what* and *how* can the education support this process?

In the tradition of didaktik questions about subject matter or content are designated as questions addressing the *material* aspect of teaching, whereas the question of how the context is organized addresses what is called the *formal* aspect.

The formal and the material aspect of education can be described as mutually dependent, and the decision of which element that are to be the determining element in a given situation must be made regarding the learning objectives. If the objectives indicates, that the students must become familiar to specific subjects, these must be taken as starting point for the planning process, and the methods afterwards be chosen regarding formulations about what skills the students must fulfil within this content. If the objectives instead indicate formal aspects – for example 'enhanced ability to self-directed learning', the content on which the methods are applied may be of minor importance, and the starting point therefore taken in the formal aspect.

Regarding project-organized, problem-oriented learning we therefore want to accentuate, that this method must be considered as one among other methods for organising learning processes, and that the specific category of guiding problem must be chosen, taking in consideration three other elements in the context of learning: The qualifications of the students, the learning objectives and the subject matter, as illustrated in the figure below.



Dealing with formal teaching and education, the choice of guiding problem and hence type of problem is always carried out within the frames of insituational learning objectives and a more or less detailed syllabus. Within the educations at Aalborg University the students formulation of the guiding problem generally are conditioned by a so called thematic frame. The thematic frame sketches a landscape indicating which theories and methods the education considers relevant for the fulfilment of the learning objectives. Thematic frames may differ in respect to how wide or narrow free rein they leave for the formulation of the guiding problem, but must – if the focus is on project-organized problem-oriented activties and not on exercises – leave a certain minimum of leeway for the students to make their own decisions.

Allthough the possibility of the students to choose whatever subject they found 'subjectively interesting' originally was one of the fundamental elements in the method of problem-

oriented, project-organized studies, the rights of the education to set up criteria for the content of the projects are now generally accepted as a relevant and to some extend nessesary condition for the use of the method in the context of formal education.

Regarding the type of guiding problem formulated in the project this normally are left solely to the decision of the students. In the article we have argued, that the type of guiding problem is determining for the specific feedback patters created through the project and hence of significant influence of the possible learning outcome.

We want to conclude this presentation by recommending that, when project-organized, problem-oriented methods are applicated, the education to a greater extend includes reflections on which *types* of guiding problems that are most suitable for supporting the learning objectives for the specific part of the education.

By this recommendation we argue that educational activities must be carried out regarding both the material and the formal aspects of the activities framing learning processes of the students.

In formal educations the possible contradiction between subjective and objective interests therefore in our opinion must be displaced in favour of the objective criteria and thereby placing the learning objectives and the structure within and relations between disciplins as the key elements, thereby ensuring that any project from the staring point contain the possibilities to fulfil the learning objectives.

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